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MEMORANDUM

SUBJECT: Technical review of the Groundwater Monitoring Report, July 2013 Additional Groundwater Sampling Event, West Lake Landfill Operable Unit 1, Bridgeton, Missouri (dated December 1, 2013)

FROM: John McKernan, Sc.D., CIH
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TO: Daniel Gravatt, RPM
U.S. EPA Region 7

This is a follow up memorandum to your e-mail dated December 2, 2013. In your e-mail, you specifically requested that we (ETSC) review the subject document and provide any observations that might help you present the information to the public.

After reviewing the document, we have presented our observations below organized into two categories: 1. High-level notes for potential presentation to the general public, and 2.Technical Summary and Observations.

High-level notes for potential presentation to the general public:

1. Attempts were made to collect a groundwater sample from all 77 wells at the Westlake Landfill/Bridgeton Landfill site in July 2013. Samples were collected from 75 of the 77 wells (one well was damaged and another well was dry). Water from both the limestone bedrock and the overlying unconsolidated sediments is sampled.

2. The discussion of concentrations below use a term called the maximum contaminant level (MCL). This is defined by the US EPA as the highest level of a contaminant that is allowed in drinking water:

- Uranium
    - All groundwater samples analyzed had concentrations less than the MCL (0.03 mg/L) for uranium.

- Thorium
    - All groundwater samples analyzed contained concentrations of thorium that would produce less than 10 picoCuries per liter of water (pCi/L, a measure of radioactivity); a radioactivity level less than 1 pCi/L was measured at most well locations. The measurements excluded radioactivity from uranium and radium.
    - The US EPA has not established a specific MCL (concentration) for thorium; however, the US EPA has an MCL for alpha-emitting particles of 15 pCi/L. This means that the amount of radioactive substance in a water sample that is capable of emitting alpha particles cannot produce radioactivity in excess of 15 pCi (equivalent to 0.555 decays per second, or dps) in a liter of water.
    - Thorium is an alpha particle emitter, but not the only one present at the site. The total concentration of alpha emitting particles was not analyzed in the groundwater samples collected. However, these results show that Thorium is not a significant source of ionizing radiation in the site's groundwater.

- Radium
    - Samples from 25 of the total 75 wells contained a radium concentration that would produce a measurable radioactivity at levels greater than EPA's radium MCL of 5 pCi/L. Note that "total" and "dissolved" radium was analyzed in each sample. Sample results were expressed in either total amount of radium, dissolved amount of radium, or total isotopic radium.
    - These 25 well locations where both up-gradient (i.e., "upstream") and down-gradient (i.e., "downstream") of the OU-1 cell at the Westlake Landfill. This may suggest that the concentration levels of radium measured at the site, even at levels exceeding the MCL, could be naturally occurring in the groundwater.

- The groundwater samples collected were from the bedrock and also from the saturated unconsolidated sediments above the bedrock.
- Coupled with the results for uranium and thorium, these data would suggest that radium is the principal source of ionizing radiation at the site.

- Trace Metals
  - Arsenic (27 of 75 wells) was detected at a concentration above the MCL.
  - The MCL (2 mg/L) for barium was exceeded at 6 well locations mostly in groundwater sampled from the unconsolidated sediments above the limestone.
  - Chromium was detected just above the MCL (0.1 mg/L), at 2 locations, in groundwater collected from both the unconsolidated sediments and another in the limestone bedrock.
  - Iron and manganese concentrations exceeded the MCL in most wells. The MCL for these chemicals is considered a "secondary" drinking water standard by US EPA – the secondary standard represents a level above which aesthetic (e.g., taste and odors) impacts may be present.
    - All of these trace metals can be naturally occurring in the sediments and rocks at the site, and at the concentrations observed in the site's groundwater. However, an assessment to evaluate whether the presence of these chemicals in groundwater was caused by natural conditions was not conducted. **Note that arsenic, iron and manganese are common to landfills where anaerobic conditions predominate.**

- Volatile Organic Compounds (VOCs)
  - 13 of 17 wells had a measured benzene concentration greater than the MCL.
  - Nine other VOCs were detected above the laboratory detection limit in at least 10 wells.
  - The majority of detections (including detections with higher concentrations) were measured in wells located adjacent to the Bridgeton Landfill site.

3. Groundwater flow
   - Across most of the site, the groundwater flow direction is generally from the southeast towards the west-northwest (toward the Missouri River).

Technical Summary and Observations:

Sample collection
- Could not find a description in the text, or notes in the April 2013 field sheets, that identified the method used for sample collection. The *Sampling and Analysis Plan* document was also not found on the Region 7 website.
- The order of sample collection was also not discussed in the text. We were unable to confidently determine that samples had been collected from wells of known lowest to highest concentrations, or other rationale used in the sample sequence.
- Duplicate sampling for radionuclides can be difficult, especially if the solids content is high in the groundwater. A description of the method used was not available, but it would appear from the results that samples are collected sequentially rather than from a split sample stream or composite. Therefore, comparison of duplicate results for sequential samples could be problematic, since the water in the original sample and the duplicate could have quite different characteristics (e.g., more or less TSS or TDS, varying pH, etc.) that could affect the sample water chemistry. A review of the sampling method may be needed.

Uranium
- The highest total uranium concentration (0.016 mg/L @ well S-53) was roughly half of EPA's acceptable concentration level for total uranium in drinking water.
- Well S-53 is generally considered to be located laterally southwest of Area 1 and up-gradient;
- The elevated uranium concentration in the sample from shallow alluvial well S-53 was likely due to the turbid quality of the groundwater sample that could be collected from this well (as stated in the report). The high solids concentration in the sample could artificially cause elevated total dissolved uranium levels (0.015 mg/L) in the sample that are not actually characteristic of groundwater quality at that sample location.
- Except for one intermediate depth alluvial well (MW-102), located on the northern perimeter of Area 2, other wells with higher concentrations were located up-gradient of both Areas 1 and 2 and also screened in the limestone bedrock along the north and south side of the permitted north landfill quarry. See notes for radium pertaining to natural sources of uranium and radium.
- There are no comparisons with data collected during previous sampling events or observations of overall trends discussed in the report.

Thorium
- Concentration levels generally were less than 1 pCi/L
- Higher activity (<10 pCi/L) samples were associated only with total (unfiltered samples) measurements. 'Dissolved' concentrations for the same samples were low or non-detectable.

Radium

- For the 25 sample locations that exceeded the MCL for total and dissolved fraction, total fraction only, or dissolved fraction only:
    - There were 3 up-gradient bedrock monitoring wells and 2 alluvial monitoring wells in Area 2 where dissolved concentrations exceeded the MCL
    - The total fraction (unfiltered samples) at 8 locations exceeded the MCL:
        - 1 upgradient alluvial well (S-53)
        - 3 up-gradient bedrock wells
        - 4 alluvial monitoring wells at Area 1
    - Combined total and dissolved fraction results exceeded the MCL at 12 locations:
        - 4 up-gradient and 1 down-gradient (Area 1) bedrock wells
        - 4 Area 1 alluvial wells
        - 3 Area 2 alluvial wells
        - Well D-87 in the Inactive Sanitary Landfill
- Comparison of data collected during previous sampling events was displayed in figures, but no discussion or observations of apparent trends in the data were specifically discussed in the report. Based on general observation only of the sample results presented in Figure 9 (RI/FS, 2012, and 2013 Results for Total Radium-226 in Groundwater) and Figure 10 (RI/FS, 2012, and 2013 Results for Dissolved Radium-226 in Groundwater) **there does not appear to be a general trend in the data at any particular sample location or any part of the site; however, further evaluation would be needed to confirm this observation**.

- Side Notes:
    - Geochemical factors that often control the concentration and mobility of radium in groundwater include (http://water.usgs.gov/nawqa/trace/radium/index.html):
        - Low dissolved oxygen (<1 mg/L) will tend to increase concentrations of radium in groundwater [Should be the condition in most areas of the site, except where compromised].
        - Low pH (<6) will allow more radium into solution and increase groundwater concentrations (A pH >6.5 seems to be the condition at most sampling locations at the site based on April 2013 sampling record).
        - High dissolved solids (Turbidity and Specific Conductance is high for many samples based on April 2013 sampling record).

    - Considering the location of occurrence, and the range of concentrations detected, much of the radium detected across the site could be attributed to naturally occurring materials in the bedrock. However, we did find an older USGS document that suggests the St. Louis formation had low radium content (http://pubs.usgs.gov/pp/0474a/report.pdf ; Page A6). There might be a more recent radium/radon reference available for areas in close proximately of the site that could be used for comparison.

Trace Metals

- Analyses were performed for 19 trace metals:
    - Arsenic was detected at 51 sample locations
        - The arsenic concentration at 24 sample locations were below the MCL (0.01 mg/L)
        - Analytical results for 27 monitoring locations exceed the MCL (total, dissolved, or both fractions)
        - Highest arsenic concentrations (0.11 to 0.4 mg/L) were in samples collected from 8 of the alluvial wells
    - Iron and manganese were detected at almost all monitoring locations
        - Iron exceeded the secondary drinking water standard (0.3 mg/L) where it occurred
        - Highest concentrations (>50 mg/L) were detected generally in alluvial wells
        - Manganese also exceeded secondary drinking water standard (0.05 mg/L) where it occurred
        - Higher concentrations (>5 mg/L) of manganese were found in both alluvial and bedrock wells
    - Arsenic, iron, and manganese are common to landfills where anaerobic conditions predominate. This statement is based on past experience and would need to be further verified.
- Trace metal data were not used to perform a geochemical characterization of the groundwater, and samples were also not collected for other basic anions and cations needed to evaluate the groundwater facies.

- Side notes:
    - Iron fouling of the wells can potentially cause erroneous results for uranium analysis due to complexation of the metal ions and other chemical changes attributed to bacteriological activity.

- Arsenic may have been deposited with the river alluvium (as an example: http://www.epa.gov/ogwdw/arsenic/pdfs/occurrence.pdf '; see pdf Page 31). Is there any data available data for arsenic in areas surrounding the site?

Volatile Organic Compounds

- Most commonly detected VOC was benzene
  - Benzene was detected in 25 of the 75 wells; samples from 13 wells exceeded the MCL of 0.005 mg/L.
  - The alluvial and bedrock wells (3 total) with the highest benzene concentrations were all measured at monitoring locations adjacent to the South Quarry Landfill
- Other detected VOCs included (highest concentrations also detected generally in wells adjacent to the South Quarry Landfill):
  - Cis-1,2-dichloroethene (18 wells)
  - Chlorobenzene (24 wells)
  - MTBE (19 wells)
  - 1,4-dichlorobenzene (13 wells)
  - Ethyl benzene (15 wells)
  - Isopropylbenzene (14 wells)
  - Xylenes (11 wells)
  - Chloroethane (10 wells)
  - Vinyl chloride (10 wells)

Groundwater Flow

- The report suggests that flow is generally to the west-northwest across the site toward the Missouri River (page 6).
- While the regional flow direction will likely be toward the hydraulic influence of the Missouri River there appears to be a more complex flow pattern across the site (OU-1).
- Although not discussed in the report, the original topographic and structural high likely centered on the former limestone quarry (north and south landfill areas). The water level data needed to confirm groundwater flow patterns is absent in the southern area beyond the site boundary; however, groundwater elevations suggest that groundwater flow radiates away from the perimeter of the landfill areas and would follow a pattern suggestive of a former structural high that likely existed before the limestone was quarried. Therefore, the 450-foot MSL groundwater contour could be inferred to extend around wells LR-105 and LR-100 and then to extend around the south landfill/quarry to join the inferred 450-foot contour shown on the map in Figure 2, between wells LCS-6B and well PZ-100-SS. If this interpretation is accurate, then flow from the site could generally be in all cardinal directions from the edge of the landfill areas. Since the north and south landfill-quarries are unlined, leachate pumping should also be reflected in the groundwater contours but isn't discussed in the report. Groundwater flow from Area 1 and Area 2, and adjacent areas north of the landfill boundaries, is generally described as toward the west-northwest.

- The wedge of alluvial sediments extends generally to the northern boundary of the permitted landfills/quarries. The alluvium is stratified and differentiated into an upper, intermediate, and deep hydraulically distinct layers or zones. The hydraulic separation is measurable at some well locations but the conditions at other well nests (e.g., S-5, I-4, and D-3) suggests that this hydraulic separation is not continuous where these deposits occur on-site. Only head differences for clustered wells were noted in the report, and it wasn't clear if a case was being made for separation of the layers in the alluvial aquifer that would control flow patterns.

- In some areas water level measurements suggest that there is an upward or downward vertical gradient (or flow) from the limestone bedrock aquifers into the alluvium. A downward vertical gradient was observed between the alluvium and limestone aquifer along the northeast corner of OU-1, Area 1 (see wells S-84, I-68, and D-85). An upward vertical gradient was observed at locations near both OU-1 areas:

  - Area 1: an upward vertical flow component was also observed at the southwest end of Area 1 (see wells PZ-113-AD, PZ-113-AS, and PZ-113-SS),
  - Area 2: at the southwest end of Area 2 (see wells S-82, I-9, and D-93).

Only head differences for clustered wells were noted in the report, and it wasn't clear if a case was being made for a hydraulic separation of the alluvial aquifer from the bedrock aquifers.

Also, it appears that these trends were observed using both wells (of unknown diameter) and piezometers. Some of the water level measurements used to demonstrate a vertical gradient were within 0.01 feet of one another (and reported to 0.0001 ft); other head differences between the alluvial wells and limestone wells were more obvious with differences of more than 1 ft observed. Caution is advised when using these data to observe small vertical gradients if well diameters are 2-inches or larger. It is also recommended that trends should only be noted when based on observations over several temporal periods.

Thank you for the opportunity to review and provide input on the subject report. Please feel free to contact me with any questions or comments.

Best regards,

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cc: Robert Weber and Gary Bertram, R7
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